1210.01 General

Hydraulic design factors can significantly influence the corridor, horizontal alignment, grade, location of interchanges, and the necessary appurtenances required to convey water across, along, away from, or to a highway or highway facility. An effective hydraulic design conveys water in the most economical, efficient, and practical manner to ensure the public safety without incurring excessive maintenance costs or appreciably damaging the highway or highway facility, adjacent property, or the total environment.

This chapter is intended to serve as a guide to highway designers so they can identify and consider hydraulic related factors that impact the design. Detailed criteria and methods that govern highway hydraulic design are in WSDOT's *Hydraulics Manual* and *Highway Runoff Manual*.

Some drainage, flood, and water quality problems can be easily recognized and resolved; others might require extensive investigation before a solution can be developed. Specialists experienced in hydrology and hydraulics can contribute substantially to the planning and project definition phases of a highway project by recognizing potentially troublesome locations, making investigations and recommending practical solutions. Regions may request that the Olympia Service Center (OSC) Hydraulics Branch provide assistance regarding hydraulic problems.

Since hydraulic factors can affect the design of a proposed highway or highway facility from its inception, consider these factors at the earliest possible time during the planning phase.

In the project definition phase, begin coordination with all state and local governments and Indian tribes that issue or approve permits for the project.

1210.02 References

(1) Existing Criteria and References

Existing criteria and additional information for hydraulic design requirements, analyses, and procedures are contained in the following references:

Hydraulics Manual, M 23-03, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Standard Plans for Road, Bridge and Municipal Construction, M 21-01, WSDOT

Standard Specifications for Road, Bridge and Municipal Construction, M 41-10, Amendments, and General Special Provisions, WSDOT

Utilities Manual, M 22-87, Section 1-19, "Storm Drainage," WSDOT

(2) Special Criteria

Special criteria for unique projects are available on request from the OSC Hydraulics Branch.

1210.03 Hydraulic Considerations

(1) The Flood Plain

Encroachment of a highway or highway facility into a flood plain might present significant problems. A thorough investigation considers the following:

(a) The effect of the design flood on the highway or highway facility and the required protective measures.

(b) The effect of the highway or highway facility on the upstream and downstream reaches of the stream and the adjacent property.

(c) Compliance with hydraulic related environmental concerns and hydraulic aspects of permits from other governmental agencies per Chapters 220 and 240.

Studies and reports published by the Federal Emergency Management Agency (FEMA) and the Corps of Engineers are very useful for flood plain analysis. The OSC Hydraulics Branch has access to all available reports and can provide any necessary information to the region.

(2) Stream Crossings

When rivers, streams, or surface waters (wetland) are crossed with bridges or culverts (including open bottom arches and three-sided box culverts), consider the following:

- Locating the crossing where the stream is most stable.
- Effectively conveying the design flow(s) at the crossing.
- Providing for passage of material transported by the stream.
- The effects of backwater on adjacent property.
- Avoiding large skews at the crossing.
- The effects on the channel and embankment stability upstream and downstream from the crossing.
- Location of confluences with other streams or rivers.
- Fish and wildlife migration.
- Minimizing disturbance to the original streambed.
- Minimizing wetland impact.

Also see the *Hydraulics Manual* Chapter 8 for further design details.

(3) Channel Changes

It is generally desirable to minimize the use of channel changes because ongoing liability and negative environmental impacts might result. Channel changes are permissible when the designer determines that a reasonable, practical alternative does not exist. When used, consider:

(a) Restoration of the original stream characteristics as nearly as practical. This includes:

- Meandering the channel change to retain its sinuosity.
- Maintaining existing stream slope and geometry (including meanders) so stream velocity and aesthetics do not change in undisturbed areas.
- Excavation, selection, and placement of bed material to promote formation of a natural pattern and prevent bed erosion.
- Retention of stream bank slopes.
- Retention or replacement of streamside vegetation.

(b) The ability to pass the design flood.

(c) The effects on adjacent property.

(d) The effects on the channel and embankment upstream and downstream from the channel change.

(e) Erosion protection for the channel change.

(f) Environmental requirements such as wetlands, fish migration, and vegetation re-establishment.

Do not redirect flow from one drainage basin to another. (Follow the historical drainage pattern.)

Consult the OSC Hydraulic section for the best guidance when channel changes are considered.

(4) Roadway Drainage

Effective collection and conveyance of storm water is critical. Incorporate the most efficient collection and conveyance system considering initial highway costs, maintenance costs, and legal and environmental considerations. Of particular concern are:

(a) Combinations of vertical grade and transverse roadway slopes that might inhibit drainage.

(b) Plugging of drains on bridges as the result of construction projects. This creates maintenance problems and might cause ponding on the structure. The use of drains on structures can be minimized by placing sag vertical curves and crossovers in superelevation outside the limits of the structure.

(c) See Chapter 630 for discussion of the relationship of roadway profiles to drainage profiles.

(5) Subsurface Drainage

Subsurface drainage installations control ground water encountered at highway locations. Ground water, as distinguished from capillary water, is free water occurring in a zone of saturation below the ground surface. The subsurface discharge depends on the effective hydraulic head and on the permeability, depth, slope, thickness, and extent of the aquifer.

The solution of subsurface drainage problems often calls for specialized knowledge of geology and the application of soil mechanics. The region Materials Engineer evaluates the subsurface conditions and includes findings and recommendations for design in the Soils Report.

Typical subdrain installations control seepage in cuts or hillsides, control base and shallow subgrade drainage, or lower the ground water table (in swampy areas, for example).

Design a system that will keep the stormwater out of the subsurface system when stormwater and subsurface drainage systems are combined.

(6) Subsurface Discharge of Highway Drainage

Consider subsurface discharge of highway drainage when it is a requirement of the local government or when existing ground conditions are favorable for this type of discharge system. Criteria for the design of drywells or subsurface drainage pipe for this type of application are described in Chapter 6 of the *Hydraulics Manual*. The criteria for the design of infiltration ponds are described in the *Highway Runoff Manual*.

(7) Treatment of Runoff

On certain projects, effective quantity control of runoff rates and removal of pollutants from pavement are intended to address flooding and water quality impacts downstream. See the *Highway Runoff Manual* for specific criteria on quantity and quality control of runoff.

1210.04 Safety Considerations

Locate culvert ends outside the Design Clear Zone when practical. See Chapter 700 for culvert end treatments when this is impractical.

1210.05 Design Responsibility

Chapter 1 of the *Hydraulics Manual* describes the responsibilities of the regions and the OSC Hydraulics Branch relative to hydraulic design issues.